

## ATTACHMENT 1

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau(43) International Publication Date  
8 August 2002 (08.08.2002)

PCT

(10) International Publication Number  
**WO 02/061304 A1**(51) International Patent Classification<sup>7</sup>: F16G 5/16Berlicum (NL) VAN DER KAMP, Johannes, Haaije  
[NL/NL]; Lombardijenlaan 373, NL-5045 WN Tilburg  
(NL); VAN LIEMPD, Jeroen, Herman [NL/NL],  
Driehoek 38, NL-4854 RM Bavel (NL)

(21) International Application Number: PCT/NL02/00005

(22) International Filing Date: 7 January 2002 (07.01.2002)

(74) Agent: GRIEBLING, Onno; Oudooibureau Griebling  
B.V., Sportweg 10, NL-5037 AC Tilburg (NL).

(25) Filing Language: Dutch

(26) Publication Language: English

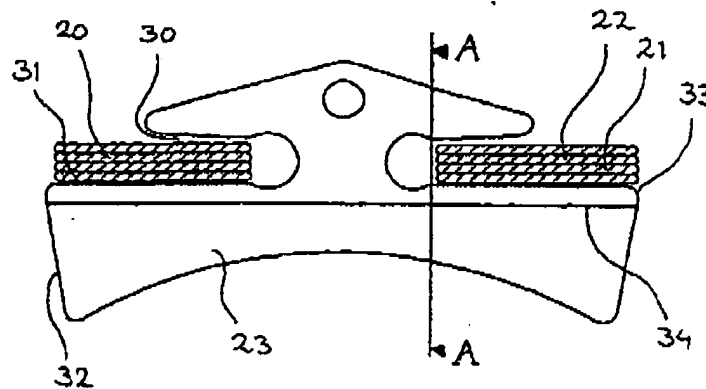
(81) Designated States (national): JP, US.

(30) Priority Data:  
1017122 16 January 2001 (16.01.2001) NL(84) Designated States (regional): European patent (AT, BE,  
CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC,  
NL, PT, SE, TR)(71) Applicant (for all designated States except US): VAN  
DOORNE'S TRANSMISSIE B.V. [NL/NL], Dr Hub van  
Doorneweg 120, NL-5026 RA Tilburg (NL).Published:  
— with international search report

(72) Inventor; and

(75) Inventor/Applicant (for US only): VAN LITH, Jo-  
hannes, Hendrikus [NL/NL]; Nijesteyn 29, NL-5258 PLFor two-letter codes and other abbreviations, refer to the "Guid-  
ance Notes on Codes and Abbreviations" appearing at the begin-  
ning of each regular issue of the PCT Gazette.

(54) Title: TRANSVERSE ELEMENT FOR A DRIVE BELT FOR A CONTINUOUSLY VARIABLE TRANSMISSION



(57) Abstract: A transverse element (23) for a drive belt for a continuously variable transmission is disclosed. The drive belt comprises two endless carriers (20), wherein transverse elements (23) are continuously arranged along the entire length of the carriers (20). The transverse elements (23) are on both sides provided with recesses (30) for at least partially receiving the carriers (20). Furthermore, the transverse elements (23) comprise supporting surfaces (31) for supporting the carriers (20), as well as pulley sheave contact surfaces (32) for the purpose of contact between the transverse elements (23) and pulley sheaves of the continuously variable transmission. A convex transition region (33) which has two parts having different curvature radii is situated between a supporting surface (31) and a pulley sheave contact surface (32), wherein a first curvature radius of a first part at the side of the supporting surface (31) is larger than a second curvature radius of a second part at the side of the pulley sheave contact surface (32).

Document 5

WO 02/061304 A1

BEST AVAILABLE COPY

WO 02/061304

PCT/NL02/00005

Title: Transverse element for a drive belt for a  
continuously variable transmission

The present invention relates to a transverse element for a drive belt for a continuously variable transmission having two pulleys having an at least partially conical contact surface for pairwise enclosing of the drive belt, each pulley being composed of two pulley sheaves, the drive belt comprising two endless carriers and transverse elements which are placed against each other in axial direction of the drive belt, wherein two subsequent transverse elements are tiltable relative to each other about a contact line, and wherein the transverse elements on both sides are provided with a supporting surface for supporting a carrier, which supporting surface transforms into a pulley sheave contact surface being designed to abut against a contact surface of a pulley sheave, through a transition region.

Such a transverse element is generally known, and is designed for application in a drive belt for a continuously variable transmission. Such a drive belt comprises two bundles of endless bands being shaped like a closed loop, which function as carriers of a number of transverse elements. The transverse elements are continuously arranged along the entire length of the bands, in order for them to be able to transmit forces which are related to a movement of the drive belt during operation.

The transverse elements are on both sides provided with recesses for at least partially receiving the bundles of bands. Further, the transverse elements comprise supporting surfaces for supporting the bundles of bands.

Furthermore, for the purpose of contact between the transverse elements and the pulley sheaves of the continuously variable transmission, the transverse elements on both sides are provided with pulley sheave contact surfaces which are divergent in the direction of the supporting surfaces. A

WO 02/061304

PCT/NL02/00005

supporting surface and a pulley sheave contact surface being situated at one side of a transverse element are connected to each other through a convex transition region. In the case of known transverse elements, the transition region has the same curvature radius along its entire length.

In case of a relatively small value being chosen for the curvature radius of the transition region, for example 0.3 mm, an advantage is that a relatively large pulley sheave contact surface is obtained. Another advantage is that also a relatively large supporting surface results. However, there are also a number of disadvantages associated with the choice of a relatively small curvature radius.

A first disadvantage is connected to the production process of the transverse elements. The transverse elements are formed from basic products being obtained by means of cutting. In practice, it was found that in case of a relatively small curvature radius of the transition region upsets arise in said region during further process steps, probably as a result of mutual contact between the basic products, or as a result of a finishing process, like in particular tumbling. Transverse elements wherein this is the case can cause damages onto the bands, especially in case of the assembly of the drive belt, wherein the carrier is pushed into a recess of the transverse element along the transition region. Damages to the bands increase the chance of for example breaking of the bands.

A second disadvantage is that a transition region having a relatively small curvature radius is more sensitive to damage than a transition region having a larger curvature radius. This effect is being contributed to by (Hertz) contact tensions which in first order are inversely proportionate to the curvature radius and which can occur in the transition region during finishing processes of the basic products of the transverse elements and during assembly of the drive belt. A damage of the transition region can cause a damage of the bands, as already indicated in the above.

Its true that applying a larger curvature radius for the transition region offers a solution to above-mentioned disadvantages, but in that case, a decrease of the pulley

WO 02/061304

PCT/NL02/00005

sheave contact surface occurs as important disadvantage. Another disadvantage is that a decrease of the supporting surface occurs, in a similar manner.

It is an object of the present invention to shape the transition region such that the disadvantages of a small curvature radius are totally or at least partially dissolved, without the occurrence of disadvantages of a large curvature radius. According to the present invention, this object is achieved by providing for a transverse element of the type being mentioned in the first paragraph, which is characterized in that the transition region comprises two parts having different curvature radii, wherein a first curvature radius of a first part near the side of the supporting surface is larger than a second curvature radius of a second part near the side of the pulley sheave contact surface.

According to the invention, a combination of two curvature radii is applied for the shape of the transition region.

Near the side of the supporting surface, the transition region has a relatively large curvature radius of for example 1.0 mm. As a result, a totally smooth surface will be obtained for the first part of the transition region during a finishing process of the basic products of the transverse elements. Moreover, damage of the first part will occur less easy. An advantageous effect of this is that the chance of damage of the bands is very small.

Near the side of the pulley sheave contact surface the transition region has a relatively small curvature radius of for example 0.3 mm. Consequently, a relatively large pulley sheave contact surface is obtained.

In an advantageous embodiment of the transverse element according to the invention, the contact line intersects the pulley sheave contact surface. This is advantageous in connection to the stability of the transverse elements during a movement of the drive belt.

In a further advantageous embodiment of the transverse element according to the invention, the pulley sheave contact surface has a surface being corrugated by means of bulges, wherein the pulley sheave contact surface is connected to the

WO 02/061304

PCT/NL02/00005

second part of the transition region through a bulge. The second part having the relatively small curvature radius then transforms directly into the bulge.

5 Furthermore, the present invention relates to a drive belt being provided with transverse elements according to the invention, as well as to a continuously variable transmission being provided with said drive belt.

10 The invention will be explained in more detail on the basis of the following description of a transverse element according to the invention with reference to the drawing, in which equal reference signs designate equal or similar parts, and in which:

15 figure 1 is a diagrammatical transverse view of a continuously variable transmission having a drive belt;

figure 2 is a diagrammatical longitudinal view of a part of the transmission having the drive belt, which is shown in figure 1;

20 figure 3a is a transverse view of a transverse element and carriers of the drive belt;

figure 3b is a longitudinal view of a section along the line A-A of the transverse element which is shown in figure 3a;

25 figure 4a is a transverse view of a detail of a transverse element according to a first preferred embodiment of the invention; and

figure 4b is a transverse view of a detail of a transverse element according to a second preferred embodiment of the invention.

30

Figure 1 shows diagrammatically a continuously variable transmission, such as for utilisation in a motor vehicle. The continuously variable transmission is indicated in general by the reference sign 1.

35 The continuously variable transmission 1 comprises two pulleys 4 and 5 being arranged on separate pulley shafts 2 and 3. An endless drive belt 6 being shaped like a closed loop is arranged around the pulleys 4 and 5 and serves for transmitting torque between the pulley shafts 2 and 3. The

WO 02/061304

PCT/NL02/00005

pulleys 4 and 5 are each provided with two conical sheaves 7 and 8 respectively 9 and 10, which collectively form a partially conical receiving groove 11 in which the drive belt 6 is received.

- 5 The transmission ratio of the continuously variable transmission is determined by the ratio of the running radii of the drive belt 6 in the receiving groove 11 of the pulleys 4 and 5. The running radii can be varied by mutually displacing the pulley sheaves 7 and 8 respectively 9 and 10 with the assistance of displacing means, which are not depicted for the sake of the simplicity. For this purpose, at least one of the pulley sheaves 7 and 8 respectively 9 and 10 is arranged in an axially movable manner. For the purpose of transmitting torque between the pulley shafts 2 and 3, the drive belt 6 is clamped inside the receiving groove 11 of the pulleys 4 and 5 with a certain clamping force.

- In figures 2 and 3a, the drive belt 6 is depicted in more detail. The drive belt 6 comprises two endless carriers 20 being disposed next to each other, which in this example are each composed of a number of bands 21 forming a bundle of bands 22. Along the entire length of the carriers 20, transverse elements 23 are arranged, wherein the transverse elements 23 are mutually adjacent to each other and are movable in axial direction relative to the carriers 20. For the sake of the simplicity, in figure 2 only a few of these transverse elements 23 are shown.

- In figure 3a, the carriers 20 and the transverse element 23 are depicted in transverse view. The transverse element 23 is on both sides provided with recesses 30 in which the bundles of bands 22 are partially received. Moreover, the transverse element 23 comprises on both sides supporting surfaces 31 on which the bundles of bands 22 are supported.

- 35 Furthermore, the transverse element 23 comprises on both sides pulley sheave contact surfaces 32. When the transverse element 23 is inside the receiving groove, contact between the transverse element 23 and a contact surface of the pulley sheave is established through said pulley sheave contact

WO 02/061304

PCT/NL02/00005

surface 32. A pulley sheave contact surface 32 and a supporting surface 31 which are situated at one side of the transverse element 23 transform into each other through a transition region 33.

5 Two subsequent transverse elements 23 are tiltable relative to each other about a contact line 34 which extends between the two transverse elements 23. As is shown in figure 3b, the contact line 34 is situated at the position where a slanting part 36 of a back surface 35 of the transverse  
10 element 23 is connected to a straight part 37 of said back surface 35. When transverse elements 23 move through, for example, the receiving groove in one of the pulleys during a movement of the drive belt, the mutual contact between two subsequent transverse elements 23 is guaranteed along the  
15 contact line 34.

In figure 4a, a detail of the transverse element according to a first preferred embodiment of the invention is depicted. With this, the transition region 33 is shown, and also  
20 adjacent parts of on the one hand the supporting surface 31 and on the other hand the pulley sheave contact surface 32. According to the invention, the transition region 33 comprises two parts having two different curvature radii. With that, a first curvature radius of a first part 40 being situated at  
25 the side of the supporting surface 31 is larger than a second curvature radius of a second part 41 being situated at the sight of the pulley sheave contact surface 32.

A suitable value of the first curvature radius is within a range of 0.5 mm to 3.0 mm, wherein, according to the  
30 invention, the value of the first curvature radius is higher than the value of the second curvature radius. Preferably, the first curvature radius has a value of 1.0 mm.

Suitably, the second curvature radius is smaller than 1.0 mm, and is in addition smaller than the first curvature  
35 radius, according to the invention. Preferably, the second curvature radius has a value of 0.3 mm.

In figure 4a, two possibilities of the known shape of the transition region having one curvature radius are depicted through dotted lines. A dotted line being indicated by the

WO 02/061304

PCT/NL02/00005

reference numeral 42 shows a possibility having a relatively large curvature radius, while a dotted line being indicated by the reference numeral 43 shows a possibility having a relatively small curvature radius. With this, insight is provided on the fact that a large curvature radius relative to a small curvature radius has the advantage that the transition region 33 has a smaller curvature and consequently is less sensitive to damages. This also implies that a large curvature radius relative to a small curvature radius has the disadvantage that the pulley sheave contact surface 32 is smaller. In the shown example of a large curvature radius, the contact line 34 intersects the transition region 33. This has a disadvantageous effect on the stability of the transverse element during a movement of the drive belt. When the transverse element is then inside the receiving groove between a pair of pulley sheaves, the transverse element will sooner be inclined to perform an undesired and disadvantageous tilting movement as a result of the relatively large radial distance between the contact line 34, where during a movement of the drive belt a pushing force is applied between the transverse elements, and an effective point of application on the pulley sheave contact surface 32 of the frictional force which appears between the transverse element and a pulley sheave.

When, in figure 4a, the transition region according to the invention is compared to on the one hand a transition region having one relatively large curvature radius and on the other hand a transition region having one relatively small curvature radius, then the advantages of the shape according to the invention appear clearly. By means of the application of two curvature radii, a shape of the transverse element wherein the contact line 34 intersects the pulley sheave contact surface 32 is possible, and wherein the contact line 34 is also situated at relatively small distance from the supporting surface 31, and with that from the carriers of the drive belt. This contributes in a positive way to the stability of the transverse element during a movement of the drive belt. Moreover, the first part 40 of the transition region 33 has a



WO 02/061304

PCT/NL02/00005

relatively small curvature, as a result of which the chance of damage is much smaller than in case of a larger curvature.

5 In figure 4b, a detail of the transverse element according to a second preferred embodiment of the invention is depicted. Just like in figure 4a, with this the transition region 33 is shown, and also adjacent parts of on the one hand the supporting surface 31 and on the other hand the pulley sheave contact surface 32.

10 In this second preferred embodiment, the pulley sheave contact surface 32 has an otherwise known surface being corrugated by means of bulges 50. In this embodiment, the pulley sheave contact surface 32 is designed to contact a contact surface of a pulley sheave through the bulges 50.

15 Preferably, the pulley sheave contact surface 32 is connected to the transition region 33 through a bulge, as is shown in figure 4b. Consequently, the second part 41 of the transition region 33 transforms directly into the bulge. An advantage of this shape is that the pulley sheave contact surface 32 extends beyond the contact line 34 as far as possible.

25 It will be clear to a person skilled in the art that the scope of the present invention is not limited to the examples discussed above, but that several amendments and modifications thereof are possible without deviating from the scope of the invention as defined in the appended claims.

WO 02/061304

PCT/NL02/00005

## CLAIMS

1. Transverse element for a drive belt for a continuously variable transmission having two pulleys having an at least partially conical contact surface for pairwise enclosing of the drive belt, each pulley being composed of two pulley  
5 sheaves, the drive belt comprising two endless carriers and transverse elements which are placed against each other in axial direction of the drive belt, wherein two subsequent transverse elements are tiltable relative to each other about a contact line, and wherein the transverse elements on both  
10 sides are provided with a supporting surface for supporting a carrier, which supporting surface transforms into a pulley sheave contact surface being designed to abut against a contact surface of a pulley sheave, characterized in that the transition region (33) comprises two parts (40, 41) having  
15 different curvature radii, wherein a first curvature radius of a first part (40) at the side of the supporting surface (31) is larger than a second curvature radius of a second part (41) at the side the pulley sheave contact surface (32).
- 20 2. Transverse element according to claim 1, characterized in that the contact line (34) intersects the pulley sheave contact surface (32).
3. Transverse element according to claim 1 or 2,  
25 characterized in that the pulley sheave contact surface (32) has a surface being corrugated by means of bulges (50), wherein the pulley sheave contact surface (32) is connected to the second part (41) of the transition region (33) through a bulge.
- 30 4. Transverse element according to any of the preceding claims, characterized in that the first curvature radius is within a range of 0.5 mm to 3.0 mm.
- 35 5. Transverse element according to claim 4, characterized in that the first curvature radius is approximately 1.0 mm.

WO 02/061304

PCT/NL02/00005

6. Transverse element according to any of the preceding claims, characterized in that the second curvature radius is smaller than 1.0 mm.

5

7. Transverse element according to claim 6, characterized in that the second curvature radius is approximately 0.3 mm.

8. Drive belt for a continuously variable transmission having  
10 two pulleys having an at least partially conical contact surface for pairwise enclosing of the drive belt, each pulley being composed of two pulley sheaves, the drive belt comprising two endless carriers and transverse elements according to any of the preceding claims, wherein the  
15 transverse elements are placed against each other in axial direction of the drive belt.

9. Continuously variable transmission, such as for  
utilisation in a motor vehicle, provided with a drive belt  
20 according to claim 8.

WO 02/061344

PCT/NL02/00005

1/4

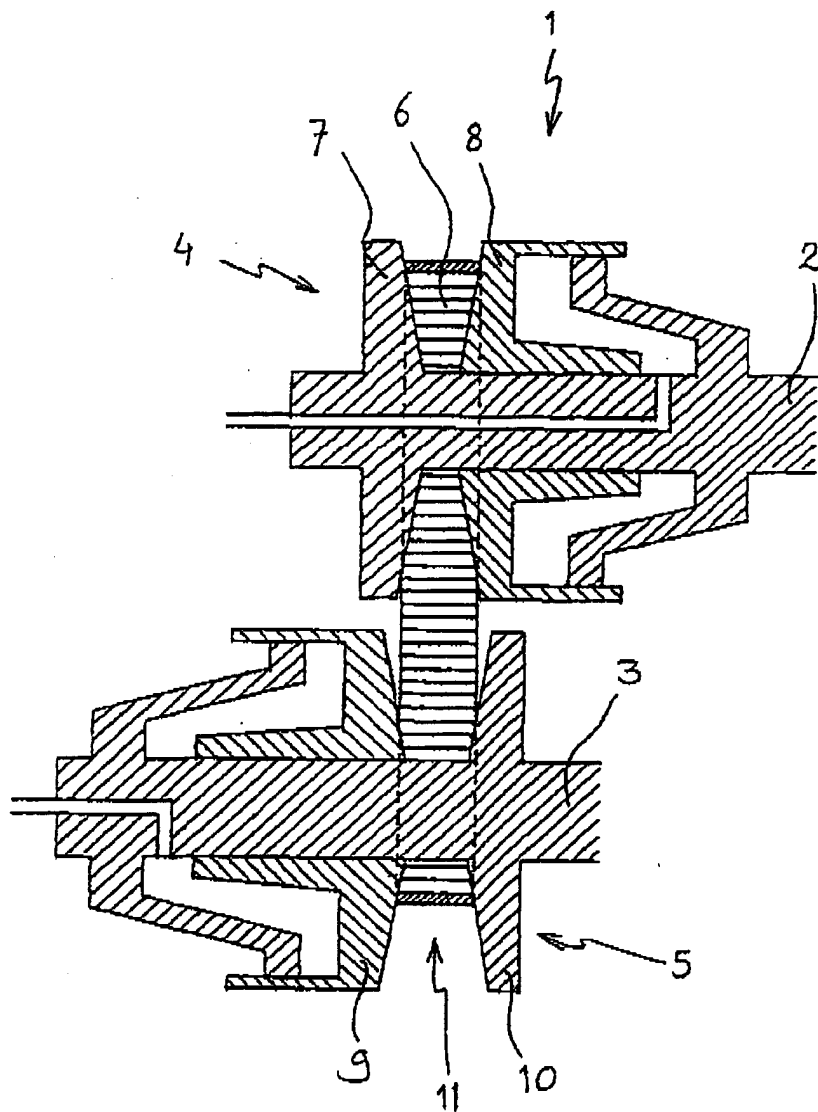


Fig. 1

SUBSTITUTE SHEET (RULE 26)

WO 02/061304

PCT/NL02/00005

2/4

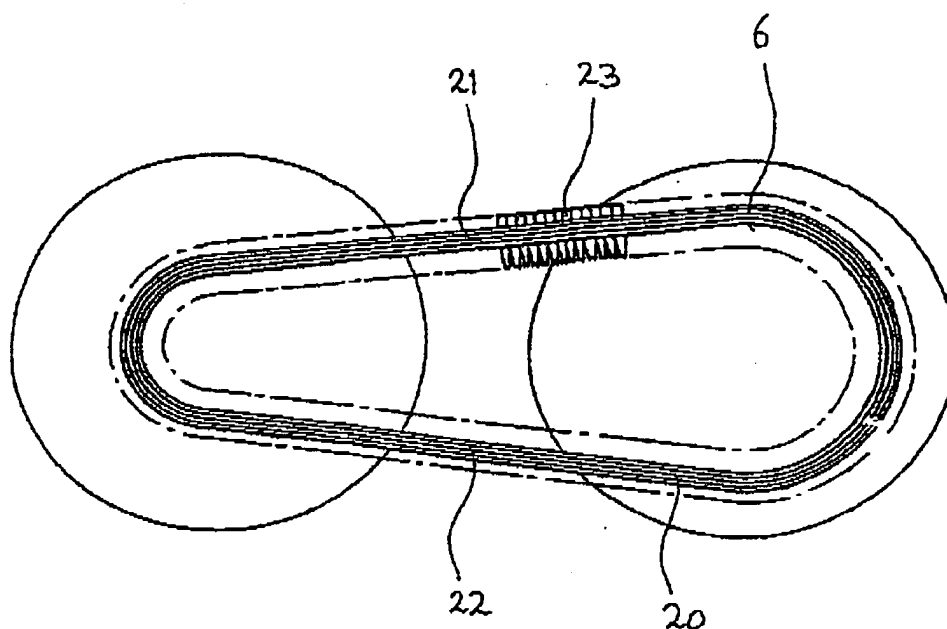


Fig. 2

SUBSTITUTE SHEET (RULE 26)

WO 02/061304

PCT/NL02/00005

3/4

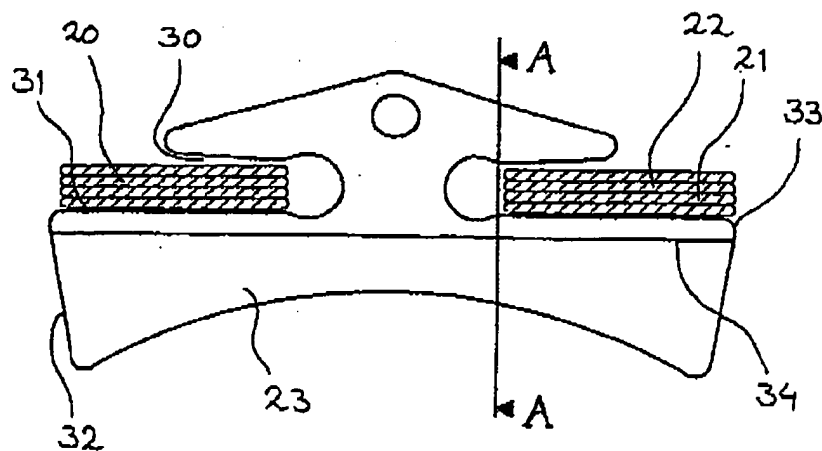


Fig. 3a

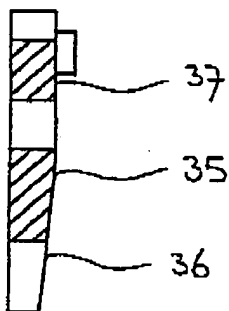


Fig. 3b

SUBSTITUTE SHEET (RULE 26)

WD 02/06/304

PCF/NL02/00005

4/4

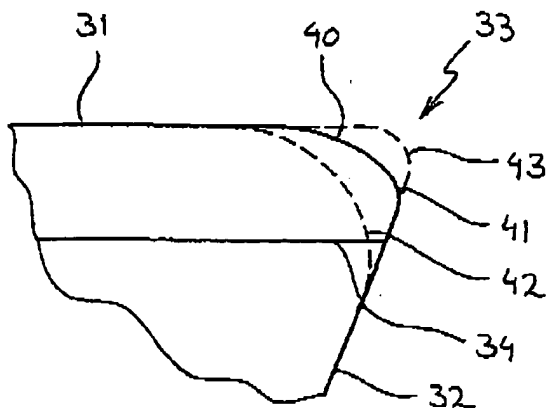


Fig. 4a

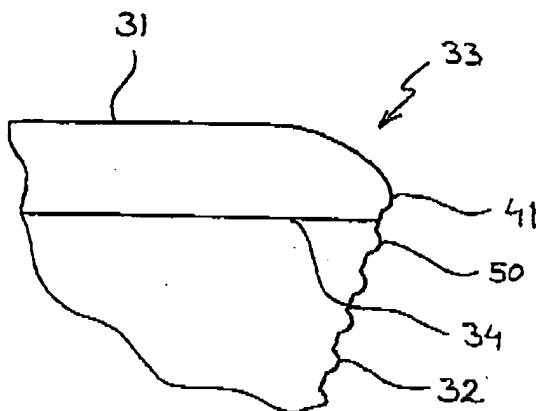


Fig. 4b

SUBSTITUTE SHEET (RULE 26)

## INTERNATIONAL SEARCH REPORT

PCT/NL 02/00005

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 7 F16G5/16

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Maximum documentation searched (classification system followed by classification symbols)

IPC 7 F16G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, WPI Data, EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
A	EP 0 367 620 A (FUJI HEAVY IND LTD ;DOORNES TRANSMISSIE BV (NL)) 9 May 1990 (1990-05-09) figures 2,4	1,8,9
A	EP 0 962 679 A (HONDA MOTOR CO LTD) 8 December 1999 (1999-12-08) figure 7	1,8,9
A	EP 0 994 275 A (DOORNES TRANSMISSIE BV) 19 April 2000 (2000-04-19)	

☐ Further documents are cited in the continuation of box C.☒ Patent family members are listed in annex.

## \* Special categories of cited documents:

- \*A\* document claiming the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another claim or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

\*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

\*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

\*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

\*Z\* document member of the same patent family

Date of the actual completion of the international search

15 May 2002

Date of mailing of the international search report

23/05/2002

Name and mailing address of the ISA

European Patent Office, P.B. 6816 Patenthuis 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl  
Fax. (+31-70) 340-3016

Authorized officer

Baron, C

Form PCT/ISA/210 (second sheet) (July 1992)



## INTERNATIONAL SEARCH REPORT

PCT/NL 02/00005

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 0367620	A	09-05-1990	JP 2125121 A	14-05-1990
			JP 2617784 B2	04-06-1997
			JP 2125122 A	14-05-1990
			JP 2652685 B2	10-09-1997
			EP 0367620 A1	09-05-1990
			US 5004450 A	02-04-1991
EP 0962679	A	08-12-1999	JP 2000055136 A	22-02-2000
			EP 0962679 A1	08-12-1999
			US 6110065 A	29-08-2000
EP 0994275	A	19-04-2000	EP 0994275 A1	19-04-2000

Form PCT/ISA/210 (patent family annex) (July 1999)

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ **BLACK BORDERS**
- ☐ **IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- ☐ **FADED TEXT OR DRAWING**
- ☐ **BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- ☐ **SKEWED/SLANTED IMAGES**
- ☐ **COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- ☐ **GRAY SCALE DOCUMENTS**
- ☐ **LINES OR MARKS ON ORIGINAL DOCUMENT**
- ☐ **REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- ☐ **OTHER:** \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**